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ABSTRACT

This paper focuses on the use of mobile-wireless technology for education. The first section is an introduction which provides a definition of the terms. The second section discusses implementation of mobile-wireless technology in schools, providing examples from Latrobe Junior High School, where wireless laptops were issued to students and River Hill High School, where personal data assistants (PDAs) were issued to students. The next section focuses on use of mobile-wireless technology in higher education; the cases of Wake Forest School of Medicine, New York Law School, and the Wharton School of Business, are provided to offer an insight into how these institutions are using this technology to enhance their learning environment and offer students a real world perspective. The fourth section examines mobile-wireless technology and constructivism, providing a definition of constructivist learning. This section provides highlights from the Pilot Laptop Program, conducted jointly by the Microsoft Corporation and Toshiba America, which saw the benefits in providing and facilitating "anytime, anywhere" learning by helping schools acquire laptop computers and software tools for students and teachers; findings of the Rockman Study, research commissioned to assess the Pilot Laptop Program's success, are also summarized. The paper concludes that the advantages of integrating mobile-wireless devices in learning environments have become evident. As technologies emerge and as learning becomes more mobile, these new devices will become commonplace in schools and universities around the world. As educational environments slowly move toward more constructivist approaches to learning, mobile-wireless devices will help provide the technological tools for it to happen. (Contains 17 references.) (AEF)

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THE USE OF MOBILE-WIRELESS TECHNOLOGY FOR EDUCATION

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I. INTRODUCTION

It was not till twenty years ago that serious progress was achieved in applying the available computer and internet technology to support teaching and learning in schools and institutions of higher education. The technology that was only available to large corporations and organization was now available in homes, schools and universities. This new shift in technology application has provided both students and educators many new advantages and learning possibilities.

Statistics show that about 75% of households in the U.S. will subscribe to a wireless service by the end of this year. Further statistics indicate that more than 75% of teachers use computers every day in the classroom, with a majority now accessing the World Wide Web for instructional purposes. (Green, 2001)

Furthering the integration of technology in schools, Federal, state, and local authorities spent an estimated $7 billion in 1999 on school computers, Internet access, software, and related items. (*Green, 2001*)

The Federal Telecommunications Act, which was passed, promised discounts on Internet access to schools and libraries. Due to this new act many schools expect to add on-line technologies to their current technology mix. (Lueker, 1997)

Computer technologies allowed students the ability to gain access to a tremendous wealth of learning opportunities, research materials, and resources that were not available to them in earlier times. Students no longer needed to rely solely on their teacher or professor or on their school or local libraries for access to information. All the resources of the World Wide Web and a multitude of other educational software applications became available to them. Students benefited by becoming actively involved in their own learning process, and were more able to proceed at their own pace. Their learning possibilities expanded and their libraries became boundary-less, learning was now elevated from local to global.

Installing new technologies in classrooms and learning environments not only benefited students, but educators have benefited a great deal as well. Teachers and educators became less tied to the time consuming task of mainly delivering lecture-based instruction. They were now able to act as coaches and guiders of students who have embarked on their learning and research journeys. Educators were now afforded the time to focus more closely on the learner's needs, and became more able to devote time to "diagnosing learning problems, developing appropriate learning strategies, and monitoring the effects of instruction". (Gillespie)

While learner centered educational environments became increasingly popular, and the application of constructivist characteristics in the design of learning environments increased. Schools and educational institutions realized that by joining the wireless revolution and utilizing wireless and mobile technology in their learning environments

they will also help enable learners become "mobile learners" who will not be constrained by time or physical location of classrooms.

> *"Schools are not going away...they are simply extending their reach beyond the physical classroom"*
>
> *Clarke, 2001*

a. Defining the Terms

- Wireless technology

It is a form of communication technology that relies on radio signals and infrared beams to gain access to bandwidth, communicate with other devices and to access the World Wide Web. This technology is being implemented in wireless modems, cellular telephones, in wireless local area networks (WLAN) and on a greater scale entire metropolitan telecommunication grids. (Green, 2001)

- M-learning

M-learning represents the marriage of mobile devices, PDAs and laptops with learning. This is the ultimate social integration of school and technology.

- Personal Data Assistant (PDA)

A monochrome or color PDA provides a little more processing power than a phone and a much larger screen. M-learning on PDAs is typically off-line, which means the content is downloaded from a PC during synching. In this case, you can view more complex data and actual lessons. (Clarke, 2001)

- Mobile Laptop Computer

Today's mobile computer is the best tool for e-learning and m-learning. It provides a full operating system, more memory, and much greater processing power. Some of the best applications for mobile computers are lecture notes, homework, interactive student chatting, mentoring, and remote access to live computer labs. (Clarke, 2001)

> *"It is important to note that the most important aspect of e-learning and m-learning is finding a way to integrate school into students' lives"*
>
> *Clarke, 2001*

The coming sections will illustrate examples of the application of mobile and wireless technology in public schools and in higher education, the technology and constructivism and final conclusions.

II. IMPLEMENTATION OF MOBILE-WIRELESS TECHNOLOGY IN SCHOOLS

Due to an attractive union of many important factors such as power, portability, and price that have recently come together in mobile-wireless devices, many schools have come to realize their potential impact. (Shields, 2002)

These new smaller devices are providing similar performance to desktop-based computers. With much more functionality features than regular graphing calculators, and less expensive than many desktop systems, the mobile computer may just become the technology that revolutionizes the face of learning. (Shields, 2002)

The flexibility of these new devices and the software applications that cater to them allow for quick and easy updates, and for efficient integration into schools. So as standards of learning and education standards are revised, software is quickly updated, and new tools are quickly designed to accommodate the changes. Software developers can quickly provide timely updates of class materials, update resources with current events, or even add new exciting activities to curriculum.

a. Integrating Mobile-Wireless Devices into Instruction

As with any new technology implementation, a learning curve must occur before seamless integration is achieved. This requires adjustments to be made on the part of educators, students and administrators. However, many teachers believe this adjustment is positive in nature and the new technology provides for greater inquiry based learning, which is based on constructivist models of curriculum.

> *"When kids have tools they can use easily, they start messing with information…it encourages them to be inquisitive."*
>
> *Shields, 2002*

In the past several years, we can see the positive impact that mobile-learning has had by considerably extending the traditional classroom beyond it's physical four walls. Through the devices students are now able to: (Clarke, 2001)

- Remotely access lecture notes
- Access assignments anywhere, anytime
- Collaborate in real time with other students
- Always have access to tutors
- Access to resources beyond the library, for research

To better illustrate the success of the implementation of mobile and wireless devices in schools we will explore two actual examples. The first is Latrobe Junior High School (LJH) in Pennsylvania, where wireless laptops were issued to students, and the second is River Hill High School (RHHS) in Maryland, where PDAs were issued to students.

b. Example: Latrobe Junior High School

> *"I love teaching, and I love books, Sure, I could teach without computers, but I wouldn't want to. We're giving this to our students so they can be well-prepared for the real world."*
>
> *Green, 2001*

In 1999 the day had come when one thousand StudyPro kid proof laptops and teacher command units were issued to students and teachers. Reality had set in when the school knew that they were on the "front lines of the wireless revolution". (*M. Green)* Because, the laptop computers do not require any network connection wires or cables to work. They are powered by built in infrared transmitter and receivers installed in each in each classroom and around the school. Through the infrared hubs students are able to access the Internet and communicate with teachers and other students.

> *"With a laptop for every student and teacher, Pennsylvania's Latrobe Junior High is virtually mobilized for success"*
>
> *Green, 2001*

The wireless laptops utilize Microsoft software, which is easily downloaded to each machine directly from the Internet. The laptops are also linked to a centrally located server in the school to access information and back up their work. In addition to the laptops, each classroom was given a laser printer, and web content that was correlated to reading materials and adhered to the state standards, and on-site training and technical support was also provided.

The teachers were issued command central laptops that are capable of controlling the StudyPro laptops issued to students. Teachers can block students from Internet access, disable automatic spell checking features, filter through email messages, and even turn students' laptops on or off.

In some classes students use their computers to write and revise essays, make edits, and print their work, they also collaborate with other classmates to review and receive feedback on their projects.

> "We really get a lot accomplished during the 40 strong minutes of class time, because the computer allows you to work quickly," says Howard. "I can see what they've written, note their edits, and make a comment right there."
>
> *Green, 2001*

While in other classes, such as a 9th grade "Technology Education" class, students send and receive notes, author detailed newspaper ads that they will try to sell, and work on designing their own dream cars. Students also log into the designated class web site to complete exams that are instantly graded, and download class assignments.

The principal and teachers at LJH have documented the effects that the laptops had on overall learning environment. They noticed that the new technology has created a

noticeable change in the way instruction and teaching are carried out in the classroom. Teachers report more frequent student-led inquiry and collaborative work. "there's more one-on-one interaction, more collaboration, and more inquiry-based, independent study" (*Green, 2001)*

c. Example: River Hill High School

> *"We're pioneers of a new educational philosophy--the next movement in education"*
>
> *Robb, 2001*

River Hill High School provides a true example of how a high school has been able to successfully implement the use of PDAs in the classroom, as tools for learning, collaboration and teaching.

> *"Wireless handhelds at River High School will help measure the link between mobile computing and student achievement"*
>
> *Robb, 2001*

450 ninth graders at RHHS received a mobile-wireless handheld PDA from MindSurf, for a study that is being conducted to measure the impact of mobile-wireless devices on student learning. The students, each equipped with their own PDA, will help to determine the future of mobile education in schools. MindSurf has chosen RHHS as the national demonstration site for the study of mobile computing and education.

The PDAs provided by MindSurf include some of the standard software that is currently being used in corporations and educational institutions, for example, Microsoft Word, Excel, and PowerPoint. The PDA also offer access to various communication and research tools such e-mail and the World Wide Web. The units are equipped with color screens and a convenient detachable keyboard. A wireless local area network was installed on the school campus to give students wireless access to communication services and other resources.

An important feature of these units is that they provide students with a multitude of tools, such as, a graphing calculator, a dictionary, thesaurus, electronic books and school-designated content. Through the units students also have access to select Internet research and reference web sites, and communication tools that allow students to share assignments and schedules. (Robb, 2001)

MindSurf has also created specific student pages that include a reference desk, homework help, and a helpful college-planning site. And teachers can link to school tools, standards information, and professional development resources. The success of the devices stems from the fact that the students provide direct input in the development and upgrade of the units. For example, student suggestions led to the addition of a French and Spanish dictionary to the tools.

The teachers that have provided feedback about the new devices indicated that "Our kids are writing more, and the units help kids stay on task. Parents can help track their assignments, which can be downloaded to home PCs."*(Robb, 2001)*

Since the inception of the project teachers are trying to integrate the devices with the school's curriculum and collaborating to help generate new ways to implement the technology.

III. USE OF MOBILE-WIRELESS TECHNOLOGY IN HIGHER EDUCATION

> *"Incorporating handheld devices and wireless Internet access into our MBA curriculum is helping us successfully implement our school's strategic focus on the role of technology in business."*
>
> *R. Dino, Assoc. Dean, University of Connecticut*

> *"The handheld became an essential tool to provide students with anytime, anywhere access to all the information they needed, and to each other,"*
>
> *Dr. Hendrickson, Wake Forest University*

With the current application of technology to learning students can take greater responsibility for their own learning. Learners are able to access information from many more resources than from just one instructor or textbook. Students can collaborate with other students on projects or for problem solving. Faculty and professors can take on the role of counselor, guide, and coach. They can focus more of their time on planning for more individualized instruction, facilitating learning and developing curriculum geared towards encouraging higher order thinking skills, and less time presenting content. *(Gillespie)*

Many universities have adopted the use of mobile-wireless devices in particular programs and colleges. The cases of Wake Forest School of Medicine, New York Law School, and the Wharton School of Business, are provided to offer an insight into how these institutions are using this technology to enhance their learning environment and offer students a real world perspective.

a. Example: Wake Forest University School of Medicine

The new curriculum offered by Wake Forest University School of Medicine recognized that students cannot realistically memorize the vast amounts of data available in growing medical subspecialties. Therefore, the school realized that it must make medical students' training more productive, and needed to teach students how to store and retrieve data they will need throughout their professional lives. *(Palm, Inc., 2002)*

To accomplish this goal the School of Medicine provided medical students who spend much of their time on direct patient care, with a handheld mobile-wireless device to carry with them on their rounds.

The medical school developed a technology solution using IBM WorkPad PC Companions that can be linked and synchronized to a centralized data server. Through this configuration student have the ability to access medical and reference information instantaneously. This provided both medical students and doctors quick access to critical information that is needed to better care for patients. The devices also enabled the users to catalog the procedures they perform on their rotations, store needed contact information, and download reference databases from the Internet to improve their diagnostic skills. What the department also noticed was that students were using

the handheld devices to take notes ON rather than scribbling them on scraps of paper as in the past. (Palm, Inc., 2002)

> *"I store in my IBM WorkPad information on drug dosing, procedures and patients, basically, all the things you can't remember, but need to. Its form factor is a huge improvement over paper, plus the search capability gives me control over the information I need, when I need it."*
>
> *Dr. Wesley Davis Department of Obstetrics*

So far, the school has acquired more than 375 IBM WorkPad handhelds. This may be the first widespread use of handhelds by a university, and Wake Forest intends to stay in the lead.

> *"The platform has the potential to revolutionize the way our medical center departments run and communicate,"*
>
> *Johannes Boehme II, Associate Dean*

To these future medical doctors and their patients, the mobility, power accessibility of the mobile-wireless platform may end up being a real lifesaver.

b. Example: New York Law School

Everyone knows that law school and legal practice can be extremely challenging. Now, the mobile-wireless handheld devices are helping to make it all easier. There was a strong case to be made for finding a way to put an enormous amount of information at the fingertips of law students and lawyers. That's what drove a group of New York Law School professors to join efforts with the school's Electronic Services Librarian, to develop an innovative website (www.jurispda.com). The website will help the growing number of law school students and professors who use mobile-wireless devices gain quick access to and download important legal information and resources. (Palm, Inc., 2002)

> *"there was a real need for a comprehensive online resource that would allow our law students to easily access the information and software they needed to use handhelds to advance their legal careers, Users can now download the legal materials and read them anytime and in almost any location, even while riding the subway."*
>
> *A. Morgan, Professor, NYLS*

Users with mobile-wireless handhelds can conduct online research and search legal-information databases, such as Westlaw; from anywhere they have wireless coverage. To help users improve time management skills that are critical to success of law students and professionals alike - there are links to applications that assist users in maintaining a schedule and staying on top of the many demands of law school and legal practice. Students can download the NYLS academic calendar, including exam schedules, to help them stay on track. The new website also enables law students, attorneys and legal scholars to organize and manage the legal data they need more

effectively than was ever before possible. Law students and others can simply download the information they need onto their devices. (Palm, Inc., 2002)

c. Example: the Wharton School Of Business

The Wharton School of Business was one of the first universities to adopt mobile-wireless handhelds into its campus culture. A project started by Wharton MBA students and the Wharton Computing and Information Technology department, is an intranet portal known as "SPIKE," The portal lets students synchronize their mobile-wireless devices with an enterprise web portal that features daily news, calendars, course materials and e-mail.

Within five years, handheld devices have grown from use by a few students to institution wide use, where nearly the entire student population relies on the devices. A year 2000 Wharton survey of students found that 88% of the 1,500 Wharton MBA students own a handheld computer. A look around the Philadelphia campus will reveal that the devices were fast becoming a must-have technology for mobile students. (Palm, Inc., 2002)

> *"The students shouldn't have to think about how or where or when to get information updates; the right information should just be there when they need it."*
>
> ***Kendall Whitehouse, Director, Wharton School of Business***

IV. MOBILE-WIRELESS TECHNOLOGY AND CONSTRUCTIVISM

a. What is Constructivism?

Constructivist learning has emerged as a prominent approach to teaching during the past decade. The work of Piaget, Bruner, and Vygotsky among others provides historical instances for constructivist learning theory. Constructivism represents a paradigm shift from education based on behaviorism to education based on cognitive theory. Constructivist epistemology assumes that learners construct their own knowledge on the basis of interaction with their environment (Driscoll, 2000).

Constructivism learning implies an initial concern with what knowledge is and how the learner actively constructs knowledge. Advocates of constructivism agree that acquiring knowledge is an active process of constructing understanding rather than the passive receipt of information.

One of the core aspects of the constructivist theory is the concept of reality and its structure; constructivism epistemology assumes that knowledge and meaning are actively constructed by the learner through authentic experiences and interactions (Hannafin, et. al. 1997).

Constructivism emphasizes a relationship between learning and experience (Ertmer & Newby, 1993). There must be experience in order for learning to take place. Constructivism treats the learner as an individual with unique perceptions and perspectives owned and constructed by that learner. Consequently, meaning is made from the learner's experiences, knowledge, and beliefs (Jonassen, 1996).

The assumption made by constructivism is that we cannot have complete knowledge of our world, therefore it doesn't' make sense to try to transmit knowledge that is ultimately unknowable and inaccurate. It argues that each individual learner in a problem solving, realistic environment constructs meaning. Some constructivist learning strategies according to Jonassen include activity, construction, collaboration, complexity, with problems embedded in authentic contexts (1996). Situated learning, as a constructivist learning strategy, includes several of those characteristics.

The goal of instruction in constructivism is not to ensure that learners know particular things but rather to show the learner how to construct plausible interpretations of those things, by using the tools that have been provided or developed in collaboration with the learners (Duffy & Jonassen, 1992). Learning is defined as personal to every individual and that is embedded in the context of the individuals' experiences and interactions with the world around them (Jonassen, 1991). The process of learning is not one of pure information transfer such as rote memorization and drill and practice. The constructivist learning environments are characterized by openness and freedom to explore, discover and construct meaningful learning. This results in a generative, learner-centered environment where students can take a hands-on approach to knowledge construction

through participation in a variety of authentic" tasks using a variety of personal and collaborative tools.

The application of constructivism is based on actively engaging learners in situations that involve collaboratively considering their own explanations for problems, phenomena, questions, etc. Learners are asked to actively construct their own knowledge by making meaning out of the situation by themselves with support, guidance and scaffolding through a facilitator. The facilitator organizes the situation and then provides encouragement and questions to the learners who are trying to construct and to display their own explanations.

The theory of constructivism has led to innovative learning environments making the most use of experience as a means to instruct. Wilson (1996) defines a constructivist-learning environment as "a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities."

b. Mobile-Wireless Technology Creating Constructivist Environments

> *"It isn't just a question of figuring out how to put technology into classrooms, It's a question of clarifying educational goals, re-conceptualizing how you orchestrate teaching and learning activities, and altering the way you assess students and teachers."*
>
> *M. Wiske, Co-Director, ETC, Harvard University*

According to researchers, schools can utilize technology effectively by supporting the changes that school reformers have been pushing for in the last decade. Many of these reforms reflect constructivist theories of learning, which urge schools to distinguish between instruction that emphasizes the transmission of information and instruction that is designed to support students' efforts to "construct" their own understanding. (Lueker, 1997)

One report explaining the link between these kinds of reforms and technology is the 1993 study, *Using Technology to Support Education Reform*. Funded by the federal Office of Educational Research and Improvement (OERI), the report surveyed research on school technology and cognitive psychology, and concluded that if a school system's goal is to develop advanced skills in thinking, analyzing, synthesizing, and experimenting, then a wide range of computer technologies can support that effort. (D. Lueker)

c. Pilot Laptop Program

The Pilot Laptop Program, conducted jointly by the Microsoft Corporation and Toshiba America, saw the benefits in providing and facilitating "anytime, anywhere" learning by helping schools acquire laptop computers and software tools for students and teachers.

The implementation involved both private schools and public school districts, for a total of 53 elementary, middle, and high schools. Participants ranged from schools with no previous computer experience to some of the most technologically advanced schools in the country. (Rockman, et al, 1998)

An independent educational research organization in San Francisco was commissioned by Microsoft and Toshiba to assess the Pilot Laptop Program's success. They also wanted to uncover the advantages and disadvantages of the program. The Research study was called the "Rockman Study"

d. Rockman Study

The goals of the Rockman study were:

- *Assess the expectations and plans for instructional use*
- *Document the changes in teaching and learning*
- *Identify strategies for effective implementation*

Rockman, et. al, 1998

The findings and results of the study were very extensive. The paper will focus on the aspects that relate to the advantages that have been realized in terms of providing for a more constructivist-learning environment.

The following sections provide a summary of the Rockman study findings and illustrate the main points gained from the laptop implementation for both teachers and students.

- **Impact on Learning**

Laptop students more frequently relied on active learning and study strategies when reading and writing. Teachers claim that the Laptop students have become more responsible for their own learning. Teachers noticed that students frequently employed active learning strategies when they read material for school. Instead of just reading and rereading to learn and remember content, Laptop students claim that they often take notes on and underline or highlight information that they read. (Rockman, et al, 1998)

Laptop students indicated that they engage more frequently in:

- rewriting/rephrasing passages from published documents
- revising reports/papers before turning them in for a final grade
- writing an outline for a paper

Each of these activities requires students' active involvement and thoughtful reflection, qualities that teachers often struggle to elicit from students.

- **The Roles Changed**

One of the themes that were uncovered was that the laptop project facilitated a noticeable change in the roles for teachers and for students. Teachers became learners and facilitators, and students were taking more of a teaching role. (Rockman, et al, 1998)

- **Students Became Teachers**

Students were helping their teachers learn how to use the new laptops. Teachers were turning to students with questions about the best way to accomplish computer and software related tasks. Students were enthusiastic to gather around the teacher's laptop computer and demonstrate. Students were surprised at how much the roles had actually shifted:

> "It's something we didn't predict: the line between teachers and students is becoming blurred. We're teaching each other"
>
> *Student*

A district administrator felt that due the teachers' own struggles in trying to learn the new technology, they increased their empathy for students, who struggled to learn subjects that were basic to teachers but new to students. Another administrator indicated that the teachers' new role as learners led to many insights into the classroom. (Rockman, et al, 1998)

> "teachers are reflecting on the best environment for them as learners. Having them articulate all that learning observation has led to renewed conversations about classroom dynamics. They're viewing themselves as learners more than as teachers"
>
> *Administrator*

- **From Teacher to Guide**

In schools where the laptops provided for increased Internet access, teachers reflected on their changing role. Students were able to tap into resources that went beyond the teacher's own knowledge, students took lead of their own learning, while teachers shifted roles from being the source of knowledge to being more of a guide or facilitator. (Rockman, et al, 1998)

> "In a traditional classroom, the teacher is the key to general knowledge; he or she knows the sources, controls the access, controls everything. ... Now teachers need to steer people through, not toward, information. The teacher is more important now as a guide to what is worthwhile"
>
> *Teacher*

- **Individualized Learning Paths**

Teachers and administrators indicated that one of the program's greatest impacts, were the Microsoft software tools on the laptop, which allowed students access to curriculum in ways that reflected their own individual needs. The tools created an even ground for all of their students. The laptop allowed them to reach more effectively the students who had difficulty learning and understanding in a traditional classroom environment, and that it provided students with the ability to pursue individualized learning paths. (Rockman, et al, 1998)

- **Different learning Modalities**

Teachers realized that the laptops impacted the way they addressed the different learning modalities students had. They were able to more effectively reach those who required more of a tactile approach: (Rockman, et al, 1998)

> *"The same students who struggle with pen and paper get very excited about laptop projects. Tactile learners can learn and show learning in different ways than with pen and paper tests"*
>
> *Teacher*

Furthermore, a number of teachers saw that the laptop helped learners who had shorter memory and attention spans while in a regular classroom environment.

> *"the laptop seems to expand their attention span, because they receive instant feedback on what's right and wrong, and instant results for their efforts. They see it right in front of them"*
>
> *Teacher*

- **Students Collaborating**

On many occasions teachers noticed that students turned to other classmates when they were faced with difficult problems that their teacher could not resolve. Students would gather around the computer of the student who was experiencing some difficulties. As one teacher indicated it was just like "group problem solving in professional settings" While the researchers were observing various classrooms they noticed that students were conferring with each other on various issues. Students would assist each other in creating tables, or in converting their information into a particular type of graph, and on group assignments. During class discussions, when one student would mention a problem they were having with their computer, many others would volunteer ideas and solutions. (Rockman, et al, 1998)

Students enjoyed the fact that they could turn to their peers for help, or would find ways to help others when they were in a predicament. One sixth grader gave an example of the times he worked with friends:

"There are some students who know every which way around the computer; you can ask them for help. Next year we'll all know what we're doing and we can help the new kids"

Student

One teacher's concern that interaction between students would decrease, because each student would be behind their own screen doing their own work, turned out to be the opposite.

"There's more interaction with peers now, such as when they're sharing an exciting idea. I worried that there would be less, with each child buried behind his or her own screen, but it's not true"

Teacher

- **Teaching Style Changes**

Given more access to software tools and laptops, teachers encountered new opportunities to test new teaching strategies that differ from their existing traditional methods they are accustomed to. The initial indications show that the laptop had an impact on teachers' pedagogy and instruction. When teachers were given the opportunity to describe their teaching styles after the implementation of the laptop project, they reported that there was a:

- 26% increase in the use of project based learning
- 7% increase student centered approach to teaching
- 3% increase in interdisciplinary approaches to teaching
- 12% decrease in the use of traditional teaching methods

Rockman, et al, 1998

The most significant change seems to be in the application of project-based instruction. This approach allows learners control over their own learning by participating in individual or small group projects. In many cases the projects are interdisciplinary and span across various topical areas, students must apply a diverse set of skills, and complete a multi-step process to reach the final product. (Rockman, et al, 1998)

Other teachers also listed the following changes to their lessons:

- Increased small group projects
- Varied task assignments
- Teaches conduct more in depth research
- Increase in the number of projects
- A focus on student organization skills
- Give students more responsibility over their own learning
- Spending more time with each student

Rockman, et al, 1998

- **Teaching Method**

Teachers indicated that due to the laptop implementation their choice of teaching method very often changed. The teachers revealed that they were more likely to employ small group and individualized learning methods, and less likely to lecture or teach in large groups. Researchers reported that, individualized learning increased by 10%, small group projects increased by 11%, and lecture style classes decreased 13%. (Rockman, et al, 1998)

Most teachers believed that the laptop program enhanced their teaching. One teacher described the increase in small group learning:

"This is the first year in 31 years when kids have not been in rows. I am not teaching the way that I have most of my career. Most of it is group learning. I have allowed the kids who learn fast to teach others"

Teacher

Another teacher also felt the program had impacted his classroom practices in substantial ways:

"it forced me to evaluate how I'm teaching: I'm doing less lecturing, more student centered activities. Also I'm now aware of amazing resources that I wasn't aware of or weren't there before...It's opened a whole new of way of working with kids"

Teacher

- **Student-centered learning**

The laptops allowed students to take control over their own learning most of the time. This brought about a more student-centered approach to teaching, where students became active participants rather than passive learners:

"The impact is on the level of students being able to acquire their own learning, to go out and do that, to be responsible for their own learning"

Teacher

"Students have to be the ones inputting the information...analyzing and filling in things they're looking for. It makes them do a lot of searching with their learning, analyzing what's needed and what's not"

Teacher

Both teachers and parents felt that this increase in the sense of responsibility was a very important benefit of the laptop program.

The Rockman Study clearly shows how the mobile-wireless laptop implementation in schools has been successful in creating a more conducive learning environment, which applies many constructivist characteristics. Teachers have shifted their

teaching methods from strict lecture based to small group and project based activities. Learners have benefited by becoming more active in their own learning and gained access to resources beyond the teacher and the textbook. Students were engaged in higher order skills, such as, analyses, synthesis and experimentation. The students have also been able to utilize real world tools to solve problems and tackle tasks, much like they will be doing in the real world. (Rockman, et al, 1998)

V. CONCLUSION

> *"The technology revolution in education will continue to be about access to information but also about ways of sharing information. Instructional technology in the next decade will support both synchronous and asynchronous interaction between the learner and the sources of knowledge and information. Incorporating digital text, audio, graphics, animation, and full-motion video into lecture, laboratory, self-study, and interpersonal and inter-group communication activities will be the norm. Real-time, simultaneous two-way video, multimedia presentations, personal support systems, and education on demand will be delivered to students where they live, work, or study. Communications and connectivity will increase between the student and the teacher, other students, the office, the dorm room, the classroom, the library, the campus, and the world"*
>
> *Gillespie*

There are many challenges that lie ahead when looking at the application of technology to teaching and learning. However, the greatest challenge is about how we identify the core and main issues of concern, which include:

1. What learning goals do we want to accomplish?
2. What is the role of technology?
3. What resources and support are available for technology implementation?
4. What are the challenges and obstacles the lay in way of technology integration?

Once these questions addressed are answered an overall systems approach must be followed. Researchers and educators must begin to outline strategies where technology has the potential to achieve the overall goals. After implementation continuous monitoring and assessment must be conducted to ensure goals are being met and strategies are being followed. In the final analysis the ultimate goal should be used to select, design, implement and support the right technology strategies that will ultimately impact how students learn. (Gillespie)

Another major challenge is the fact that teachers need to be fully trained on how to use and teach with technology. Otherwise, all the hardware in the world won't improve education. (Gordon)

It was disappointing to know that schools spent less than 5% of their educational technology budget on training, where teachers on average, received a total of only four hours annually. With new hardware and software technologies constantly emerging it is crucial that teachers are kept up to speed, and at the front end of these new technologies. After all they are required to educate the coming generations. (Gordon)

Many schools around the country have access to state-of-the-art technology, but the saddening fact is that nobody knows how to use it. The fact is that teachers haven't received adequate training on how to integrate technology into daily classroom instruction. And technical support is often unavailable or insufficient. Closing the digital

divide that surrounds teacher training must become a priority. Major changes and concerted effort must be applied to solving this widespread problem. (Gordon)

The advantages of integrating mobile-wireless devices in learning environments have become evident. As technologies emerge and as learning becomes more mobile, these new devices will become commonplace in schools and universities around the world. As educational environments slowly move toward more constructivist approaches to learning, mobile-wireless devices will help provide the technological tools for it to happen.

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